PATENT SPECIFICATION

Application Date: Sept. 17, 1935. No. 25798/35.
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One Complete Specification Left: Oct. 15, 1936.
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PROVISIONAL SPECIFICATION
No. 25798 A.D. 1935.

Improvements in Variable Pitch Airscrews and the like

We, CYRIL DELL, of "Muros," Hall Park Gate, Berkhamsted, Hertfordshire, and HERBERT LOUIS READ, of "Netherton," Herington Grove, Hutton, Essex, both British subjects, do hereby declare the nature of this invention to be as follows:—

This invention relates to airscrews of the kind provided with means to vary the pitch in infinite stages between coarse and finer limits, and wherein the varying pitch angle is determined automatically. It is known, for example, to vary the pitch automatically under different conditions of "thrust" (horizontal pull) which is utilised to bring about a longitudinal movement of the airscrew boss on the propeller shaft, said movement in turn being employed to alter the pitch of the blades. The object of the present invention is to employ both thrust and torque (of the propeller shaft) as component forces in securing automatic pitch variation, and thereby to ensure correct pitch angles during taking off and climbing. During these conditions there is risk of blade stalling, thrust becoming reduced to a negligible degree and consequently there would occur no actuation of the pitch-varying mechanism dependent solely on thrust.

According to the invention the air screw boss, carrying mechanism for varying the pitch angle of the blades, is mounted on the propeller shaft with a limited degree of rotational play which automatically operates the said mechanism. This rotational play is translated simultaneously into a limited longitudinal movement of the boss along the shaft against a suitable resisting force. The arrangement is such that, at rest or during idling conditions, the resisting force holds the boss in a normal position wherein the blades are set at the coarsest pitch, but on accelerating the rotation of the propeller shaft, the torque transmitted from shaft to airscrew brings about a longitudinal movement of the screw unit on the shaft due to the inertia of the screw and to the air resistance encountered thereby which produces the aforesaid relative rotational play between screw and shaft. This relative rotational movement operates the pitch-varying mechanism to move the blades to a finer pitch angle.

In this manner, the screw now with a finer pitch, develops an increasing static thrust which, added to the torque, still further operates the mechanism by exerting a force to move the screw unit along the shaft. This progressive action, tending to vary the pitch towards the fine position, continues until the thrust value reaches a maximum and the torque decreases; the aforesaid resisting force holding the boss in the normal position exerts itself, moving the screw assembly along the shaft back to or towards the normal position, bringing about a reversal of the relative rotational movement, and again varying the pitch angle from a fine degree towards coarse. In flight, at high speeds, the thrust diminishes, and thus the force thereof which would tend to move the screw unit longitudinally along the propeller shaft (varying the pitch in the direction of a smaller pitch angle as was obtained by the starting torque) is negligible or countered by the resisting force. When, however, thrust develops in excess of a predetermined degree, sufficient to overcome the resisting force, the screw unit will move in a direction to lessen the pitch angle.

An embodiment of the invention will be described by way of example.

The airscrew boss is a hollow housing for the pitch-varying mechanism and has a central bore by which it is slidably and rotatably mounted on the propeller shaft or an extension thereof. The roots of the blades are pivoted in suitable bearings in the boss, and each fixedly carries inside the box a bevel pinion. These blade pinions mesh with a crown wheel disposed inside the boss, coaxial with the central bore, said crown wheel being splined on the propeller shaft. It will thus be seen that the complete boss assembly is freely

slidable on the shaft and that rotation of the propeller shaft relatively to the boss will cause rotation of the blade pinions by virtue of their gearing with the relatively rotating crown wheel.

The propeller shaft, or an axial extension thereof, projects through the boss and carries an end plate, bridge or the like on which are mounted in any suitable manner a number of compression springs seated between the end plate and the boss. These springs constitute the aforesaid resisting force normally acting to keep the boss and its blades, i.e. the screw unit, pressed away from the free end of the propeller shaft. The spring arrangement would be disposed on the engine side of the boss for pusher type screws.

The boss is mounted on the shaft by any suitable means to effect a driving engagement between shaft and screw unit with the limited rotational play hereinbefore described. For example, integral with the rear or engine face of the boss there may be a number of inclined abutments or ramps held in driving engagement with a number of radial pins extending from the propeller shaft. Thus, rotation of the shaft (with the screw unit held, as by inertia) will move the pins against their ramps, bringing about a simultaneous relative longitudinal and rotational movement of the screw unit, which causes actuation of the pitch-varying gear against resistance of the aforesaid compression springs. The ramp profile may be straight-line in development or any requisite curve calculated and designed to suit any particular engine or other given conditions.

The said resisting force may be variable under the control of the pilot. For instance when springs are employed as in the foregoing embodiment they may be adjustably compressed by hydraulic or other force controlled from a remote point.

It is to be understood that any suitable gear may be used whereby the relative rotational movement aforesaid can be utilised to turn the blades, and also, any suitable method may be adapted to cause the longitudinal movement of the screw unit as and when the aforesaid relative rotation takes place.

Although the invention is intended primarily for airscrews, the constructional principles are also applicable to marine and other screw propellers.

Dated this 17th day of September, 1935.

EDWIN C. AXE, A.I.M.E.,
27, Chancery Lane, London, W.C.2,
Agent for the Applicants.

PROVISIONAL SPECIFICATION
No. 12174 A.D. 1936.

Improvements in Variable Pitch Airscrews and the like

We, Cyril Dell, of "Muros," Hall Park Gate, Berkhamsted, Hertfordshire, and Herbert Louis Read, of "Netherton," Herington Grove, Hutton, Essex, both British subjects, do hereby declare the nature of this invention to be as follows:—

In our co-pending Provisional Specification No. 25798/35 there is described an improvement in air screws of the automatically variable pitch kind. According to the said co-pending Specification, the air screw boss, carrying mechanism for varying the pitch angle of the blades, is mounted on the propeller shaft with a limited degree of rotational play which automatically operates the said mechanism. This rotational play is translated simultaneously into a limited longitudinal movement of the boss along the shaft against a suitable resisting force. The arrangement is such that, at rest or during idling conditions, the resisting force holds the boss in a normal position wherein the blades are set at the coarsest pitch, but on accelerating the rotation of the propeller shaft, the torque transmitted from shaft to airscrew brings about a longitudinal movement of the screw unit on the shaft due to the inertia of the screw and to the air resistance encountered thereby which produces the aforesaid relative rotational play between screw and shaft. This relative rotational movement operates the pitch-varying mechanism to move the blades to a finer pitch angle.

The said resisting force is provided, in one embodiment, by a suitable number of compression springs mounted between an end plate fixed to the propeller shaft and the slidable propeller boss.

According to the present modification the springs are encased and constructed as dashpots or hydraulic shock absorbers or replaced by springless dashpots so as to render the mechanism non-responsive to rapidly fluctuating loads such as the pulsations arising from an internal combustion engine.

The dashpot may be of any suitable known or other construction. For example, the spring may be housed in an oil

chamber, interposed between a piston and one end of the chamber, the piston rod being connected to the load (i.e. to the movable propeller boss). The piston, in this case, is constructed to allow leakage at a given rate such as by making it a very free fit in the oil chamber, or by perforating it. In another form both ends of the chamber may be furnished with interconnected ports having a suitable flow-adjusting valve in the exterior connecting pipe.

In the latter form of dashpot the pitch varying mechanism may be made inoperative, by manual or other control of the valve. One common valve may be used for a plurality of dashpots.

An interconnecting port system as described may be made common to all dashpots by utilising a hollow propeller shaft, such an arrangement facilitating remote control.

Dated this 29th day of April, 1936.

EDWIN C. AXE, A.I.M.E.,
27, Chancery Lane, London, W.C.2,
Agent for the Applicants.

COMPLETE SPECIFICATION

Improvements in Variable Pitch Airscrews and the like

We, CYRIL DELL, of "Muros," Hall Park Gate, Berkhamsted, Hertfordshire, and HERBERT LOUIS READ, of "Netherton," Herington Grove, Hutton, Essex, both British subjects, do hereby declare the nature of this invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to automatically operating variable pitch airscrews of the type wherein the airscrew hub assembly is mounted for limited relative rotation and axial sliding on the driving shaft, under the action of varying thrust and torque.

In known variable pitch airscrews of this type the construction is such that increase (or decrease) of torque causes the blades to turn in one direction and increase (or decrease) of thrust causes the blades to turn in the opposite direction, that is to say the resulting pitch angle is due to the difference of blade adjustment caused by thrust and torque respectively

According to this invention, in a variable pitch airscrew of the type specified the hub assembly connecting the blades to the shaft is so constructed that like variations of thrust and/or torque cause the blades to turn in the same direction, the pitch angle being reduced when thrust and/or torque increases and being increased when thrust and/or torque decreases.

It will be seen that while in known airscrews of the specified type the effect of thrust and torque variation on the pitch angle is subtractive, in the airscrew according to the invention the effect of thrust and torque variation on the pitch angle is additive.

In one embodiment of the invention the hub assembly comprises two main parts which respectively provide for the rotational and axial movements hereinbefore referred to. The airscrew boss, in which the blades are rotatably mounted in known manner, is one part and is mounted on the propeller shaft for restricted relative rotational movement in response to torque variation and is connected to the other part, which is a member slidable but non-rotatable on said shaft, for restricted axial movement therewith in response to thrust, means being provided to cause the blades to assume a finer pitch position when said boss and member are moved in one direction under the action of increasing thrust and/or torque.

Means are provided to move the boss and said slidable member in the opposite direction, thereby causing the blades to assume a coarse pitch position and said means becomes operative when there is a decrease of thrust and/or torque. This means, responsive to thrust and/or torque decrease, comprises pressure means, such as springs or fluid under pressure or both.

An embodiment of the invention will now be more particularly described with reference to the accompanying drawings, wherein:—

Figures 1 and 2 are part sectional side elevations, showing the forward end of the propeller shaft, pitch varying mechanism and roots of the blades;

Figures 3 and 4 illustrate modifications of the aforementioned pressure means; and

Figure 5 shows a fragment of the propeller shaft and boss with means for effecting the initial setting of the pitch angle.

Referring to Figures 1 and 2, the airscrew boss 1 is mounted for restricted relative rotational movement on the propeller shaft 2 and is connected to a sleeve 3 splined on the propeller shaft. The sleeve 3 is the aforesaid member which is slidable but non-rotatable on the propeller shaft. The boss 1 is connected to the propeller shaft by means of axial studs

or trunnions 4 fixed to the shaft and carrying anti-friction rollers 5 engaging in cam slots 6 of the boss 1. The sleeve 3 is formed with a bevel crown wheel 7 meshing with bevel gears 8 on the roots 9 of the blades, which are set to the coarsest pitch angle position when the parts are in the position shown in Figures 1 and 2.

Assuming the airplane to be stationary the airscrew will endeavour to resist acceleration on rotation, owing to the inertia of its mass and the air resistance encountered, therefore the propeller shaft 2 will perform angular movement relatively to the boss. The sleeve 3 partakes in this relative rotational movement and thereby causes the blades to rotate so as to assume a finer pitch angle. Obviously, such relative rotation will occur when torque is increasing, that is to say when the boss and blade assembly put up an increasing resistance to rotation by the propeller shaft through the aforesaid connection. The term "increasing torque" shall include the torque at which the said relative rotation takes place and any higher torque, disregarding thrust as the cause of such rotation. Obviously also, increasing thrust will cause the boss assembly, including the boss, the sleeve 3 and the blades, to move axially in the forward direction which, owing to the described connection between propeller shaft and boss, will also bring about relative rotation and thereby reduction of pitch angle. Therefore, on taking off, high initial torque will cause a reduction of the pitch angle from coarsest to finer and also an increase of thrust, and this increase of thrust will cause further reduction of pitch angle.

Means are provided to limit both the extent of said relative rotation and said axial movement of the boss assembly and such limiting means are identical with the means responsive to torque and thrust decrease for increasing the pitch angle. Such means comprise pressure means, such as springs or fluid under pressure tending to oppose the forward movement of the boss assembly.

In Figures 1 and 2 both springs and fluid under pressure are employed. A number of pistons 10 are fixed to the sleeve 3, said pistons being parallel to the propeller shaft 2 and working in cylinders formed in a casing 11 fixed to the forward end of the shaft. Compression springs 12, tending to push the boss assembly towards the engine (coarse pitch position of the airscrew blades), are disposed between one end wall of the casing 11 and the pistons 10. The propeller shaft 2 has an axial duct 13 leading to a cylindrical bore 14 in the forward end of the shaft. A plunger 15 is disposed in the bore 14 and is subject to the action of a compression spring 16 which tends to move the plunger to that end of the bore at which the duct 13 terminates. The bore 14 communicates through radial ports 17 in the shaft and cylinder ports 18 with the cylinders of pistons 10. The output of a pump driven by the engine is connected to the duct 13 and is also by-passed to the pump input. A valve, controllable by the pilot, is disposed in the by-pass, so that fluid pressure in the duct 13 is regulable. When it is desired to augment the resistance of the springs 12 the valve is throttled, whereby the pressure in duct 13 increases, plunger 15 is pressed forward and fluid under pressure is supplied to the pistons 10 through ports 17 and 18. With constant valve setting the pressure of the fluid will depend upon engine speed, that is to say the greater the engine speed the more the blades will be turned into coarse pitch position.

In the modified embodiment shown in Figure 3 the plunger 15 and its spring 16 are omitted and the duct 13 communicates directly through the ports 17 and 18 with the cylinders of pistons 10.

In the embodiment shown in Figure 4 the pistons 10 move in dashpots having ports 19 on each side of the pistons, these dashpots acting as hydraulic shock absorbers so as to render the mechanism non-responsive to rapidly fluctuating loads, such as the pulsations arising from the engine.

It is to be understood that the fluid pressure means may be omitted, relying on spring pressure alone, or the springs may be omitted relying on fluid pressure alone. In a further modification (not shown) a single annular piston may be employed in place of the individual pistons 10, working in a corresponding annular cylinder. This embodiment is of advantage where a large piston area is desired.

In the embodiment shown in Figure 5 the cam slots 6 are formed in a flanged hub 20. The edge of the flange is serrated and engages with a serrated edge of a ring 21, the other serrated edge of which engages with the serrated rear edge of the boss 1. The spacing of the serrations at the two sides of the rings 21 is made on the well known vernier principle, so that by relative rotation of the parts 20, 21, the angular position of the boss 1 relatively to the flanged hub 20 may be adjusted within very fine limits and thus the blades may be set as desired to the initial coarse pitch position.

In Figures 1, 2 and 5 the cam slots 6 are shown having straight edges. However, the edges may be curved in adapta-

tion to torque and thrust ratio obtaining in any particular airplane, thereby assuring that pitch variation takes place in the most favourable manner in a given set of circumstances.

It is understood that any suitable means, other than described, may be employed to effect a driving engagement between shaft and boss. Furthermore, any suitable gear may be used whereby the relative rotational movement aforesaid can be utilised for turning the blades, and also, any suitable method may be adopted to cause the longitudinal movement of the screw unit as and when the aforesaid relative rotation takes place.

Although the invention is intended primarily for airscrews, the constructional principles are also applicable to marine and other screw propellers.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A variable pitch airscrew of the type specified, wherein the hub assembly connecting the blades to the shaft is so constructed that like variations of thrust and/or torque cause the blades to turn in the same direction, the pitch angle being reduced when thrust and/or torque increases and being increased when thrust and/or torque decreases.

2. A variable pitch airscrew according to Claim 1, comprising a plurality of blades rotatably journalled in a boss mounted on the propeller shaft for restricted relative rotational movement in response to torque variation and connected to a member, non-rotatable but slidable on said shaft, for restricted axial movement therewith in response to thrust variation, means being provided to cause the blades to assume a finer pitch position when said boss and member are moved in one direction under the action of increasing thrust and/or torque.

3. A variable pitch airscrew according to Claim 1 or 2, wherein means responsive to thrust and torque decrease for turning the blades into coarse pitch position comprise pressure means, such as springs and/or fluid pressure.

4. A variable pitch airscrew according to Claim 2, wherein a cam slot and pin connection is provided between the propeller shaft and the boss and the member non-rotatable on the shaft is geared to the blades so as to cause rotation of the blades when the boss performs movement relatively to the shaft.

5. A variable pitch airscrew according to Claim 3, wherein the means responsive to thrust and torque decrease comprise springs supported between a member fixed to the propeller shaft and the member non-rotatably mounted on the shaft and connected to the boss.

6. A variable pitch airscrew according to Claim 5, wherein the springs are supported between a member fixed to the propeller shaft and formed as a dashpot and pistons fixed to the member non-rotatably mounted on the shaft.

7. A variable pitch airscrew according to Claim 5, wherein the springs are mounted in cylinders formed in a casing fixed to the propeller shaft and act upon pistons fixed to the member non-rotatably mounted on the shaft, fluid under pressure being supplied to the cylinders through the propeller shaft in such direction as to augment the pressure of the springs.

8. A variable pitch airscrew according to Claim 7, wherein fluid under pressure is supplied to the cylinders through ports in the propeller shaft controlled by a plunger working in a cylindrical bore of the shaft.

9. A variable pitch airscrew according to Claim 7, wherein a single annular piston is provided, working in a corresponding annular cylinder.

10. A variable pitch airscrew according to Claim 4, wherein the sides of the cam slots are straight.

11. A variable pitch airscrew according to Claim 4, wherein the sides of the cam slots are curved in accordance with the torque and thrust ratio obtaining in the particular airplane to which the airscrew is applied.

12. A variable pitch airscrew according to any of the preceding claims, wherein the boss is connected to the propeller shaft through a vernier device, whereby the initial angular position of the boss relatively to the shaft and consequently the initial pitch of the blades, may be set.

13. A variable pitch airscrew according to any of the claims 3 to 12, wherein the force exerted by the pressure means is controllable by the pilot.

14. A variable pitch airscrew, substantially as herein described with reference to the accompanying drawings.

Dated this 15th day of October, 1936.
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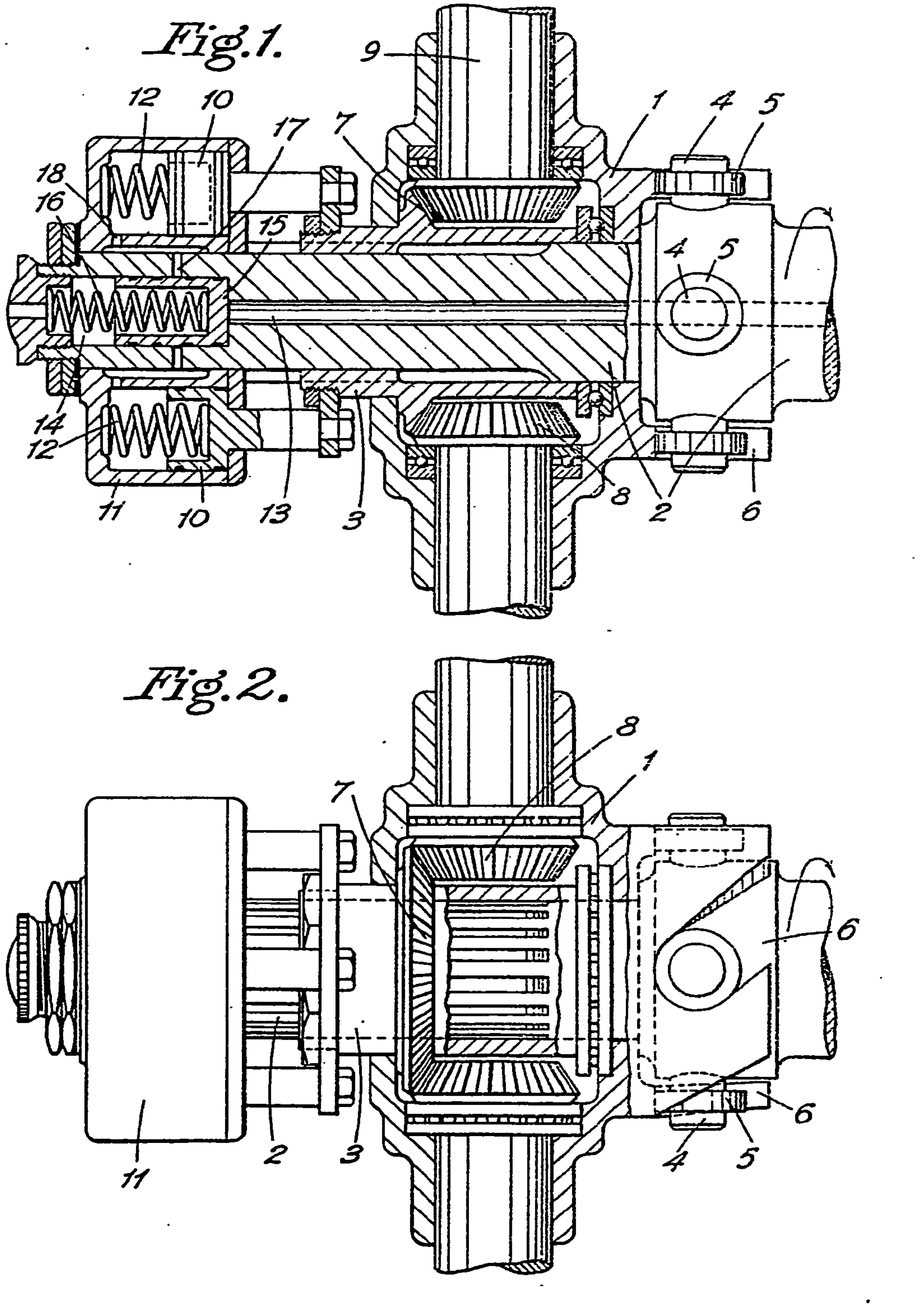
Agent for the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

SHEET



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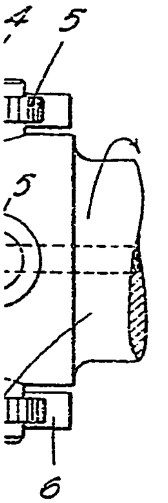

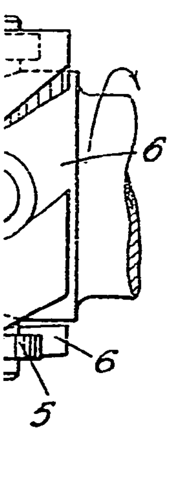

Fig.3.

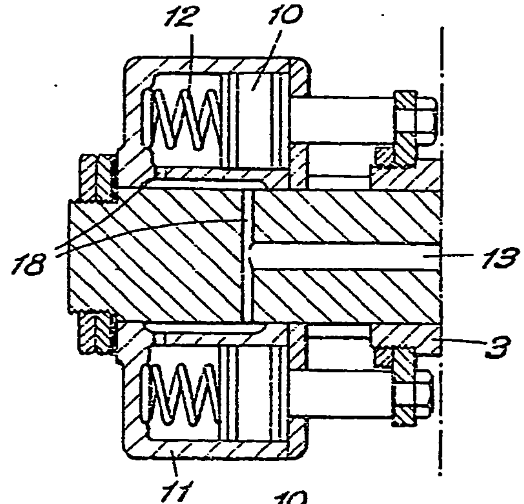

Fig.4.

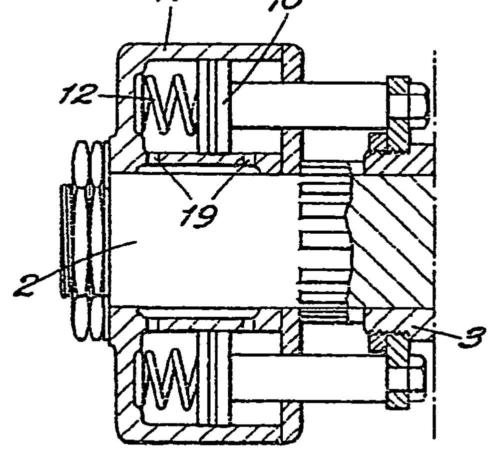

Fig.5.

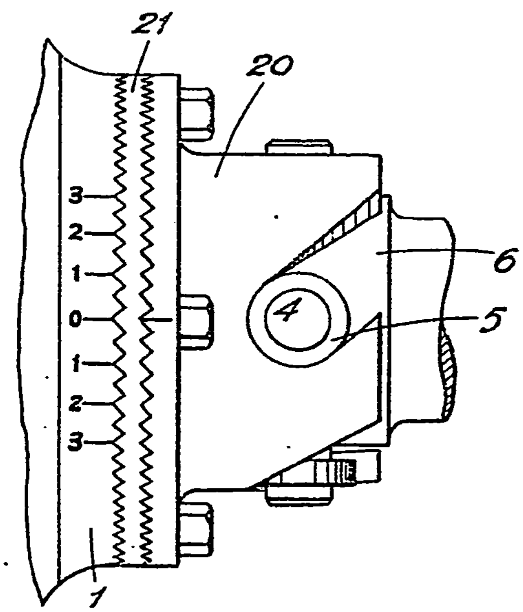

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Fig.1.

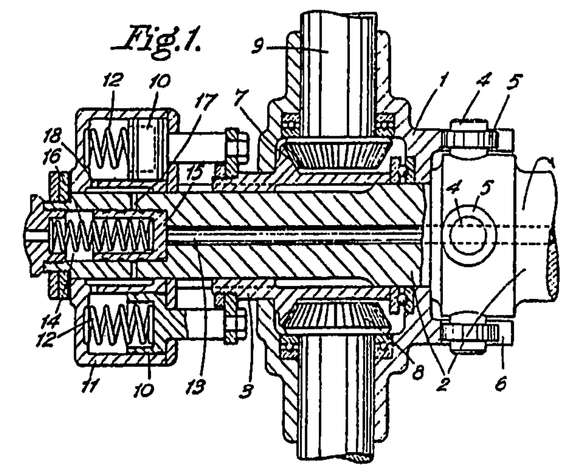

Fig.2.

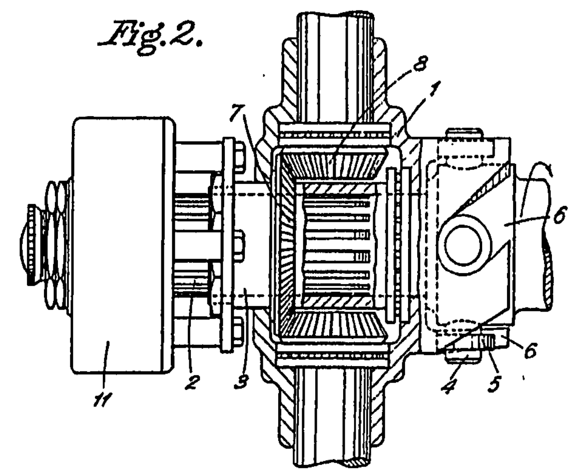

Fig.3.

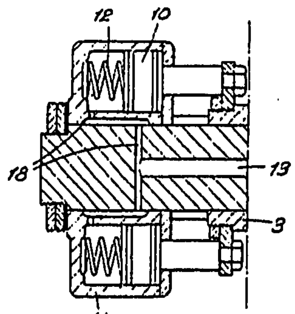

Fig.4.

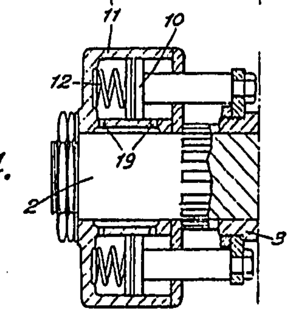

Fig.5.